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SWEET-POTATO STORAGE STUDIES.[1]

By H. C. THOMPSON, formerly *Horticulturist*, and JAMES H. BEATTIE, *Horticulturist, Office of Horticultural and Pomological Investigations.*

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IMPORTANCE OF THE SWEET-POTATO CROP.

The sweet potato is second in importance of the vegetable crops, being exceeded in value only by the Irish potato. In 1920 approximately 1,085,000 acres of land in the United States were devoted to the production of sweet potatoes. The estimated production was 112,368,000 bushels, with a farm value of $126,629,000. The greater portion of the crop is produced in a few of the Southern States, the important producing States being Alabama, Georgia, Mississippi, North Carolina, Texas, South Carolina, and Louisiana.

[1] During the progress of this work assistance was rendered by H. M. Conolly, formerly assistant horticulturist; F. E. Miller, formerly horticulturist; and C. J. Hunn, assistant horticulturist, Office of Horticultural and Pomological Investigations.

PRELIMINARY STUDIES.

In preparing for this investigational work on sweet-potato storage a study was made of the industry in the South. It was found that storage and marketing were by far the most serious problems confronting the grower at that time, but it was evident that little could be done on the marketing problem until the storage problem was solved. At the time these studies were made, careful estimates indicated that on the average the loss by decay was fully 30 per cent of the sweet potatoes stored in pits or banks, the common method of caring for the crop in the South, while in many cases the loss was complete. In addition to the loss due to storage rots, it was found that these potatoes were poor in quality when removed from the pits and decayed rapidly after they were placed on the market. From these preliminary studies it was evident that experimental work on sweet-potato storage was needed, especially in the South, where the bulk of the crop is grown, and that some method of storage was desirable which would give better results than the pit and bank methods.

Various types of storage houses had been used in some of the sweet-potato growing sections, but at this time there were very few storage houses in the South, and practically none of these were in the sections of States producing large crops of sweet potatoes. Various commercial sweet-potato regions, including New Jersey, Delaware, Maryland, Illinois, Iowa, and a few in the South, were visited, and studies were made of the types of storage houses and the materials and methods used in their construction, ventilation, heating, and management. The methods employed in harvesting and caring for the sweet-potato crop were also noted, and a study was made of the results obtained in the various types of houses under the different methods employed in handling the sweet-potato crop. From these observations it was thought that the first step should be to devise a type of house that would meet the needs of the South. The good features of all the storage houses that had been visited were combined and a plan was made by the senior writer in 1912. This plan, somewhat modified, was later published in Farmers' Bulletins 548 and 970.

In 1912 a few houses were built in Alabama and Mississippi, according to these plans, and observations were made on the keeping of sweet potatoes in them. This work was done during the first year in cooperation with the agricultural colleges in Alabama and Mississippi, but after that active cooperation ceased. The work was continued in these and other States by the Office of Horticultural and Pomological Investigations of the Bureau of Plant Industry. The houses built in 1912 were so successful that they served as demon-

strations and object lessons, with the result that thousands of similar houses are now in use.

OBJECTS OF THE EXPERIMENTS.

Many problems arose relative to the management of storage houses built according to the plans as originally made and as modified from time to time. It became apparent that more information was needed on the problems involved. These were—

(1) The factors which hasten the decay of sweet potatoes in storage.

(2) The best methods of reducing the losses due to decay and to excessive shrinkage.

(3) The effects on shrinkage and decay of different methods of handling sweet potatoes.

(4) A comparison of varieties of sweet potatoes with reference to loss in storage from shrinkage and decay.

(5) The effects on the keeping quality of sweet potatoes of temperature and humidity in the storage house.

METHODS OF PROCEDURE.

Experimental work on sweet-potato storage was begun in 1912 and has been continued every year since. During the first four years all the experiments were conducted in houses owned and controlled by farmers or commercial firms, and the management was not entirely under the control of the investigators. During the five years 1916–17 to 1920–21, inclusive, the work was carried on in a storage house erected for this purpose on the Arlington Experimental Farm at Rosslyn, Va. This house has been under the complete control of the investigators.

In all of the experiments it was the aim of the investigators to have all the conditions identical, with the exception of the particular one being studied. Where the conditions were not alike the results are not considered in this bulletin.

In all the experiments conducted in storage houses the sweet potatoes were subjected to a curing process for a period of two or three weeks, the length of time depending upon the weather and the condition of the potatoes. The curing consists of reducing the moisture content of the potatoes by means of artificial heat with thorough ventilation. The temperature during the curing period was usually maintained between 80° and 90° F. by means of heating apparatus until the potatoes were cured, as evidenced by the "feel" when handled or by the appearance of sprouts. When the potatoes were cured the temperature was gradually lowered to the desired point. The average temperature maintained in the different rooms in the experimental house is shown in figure 1.

Ventilation was provided by means of openings in the floor and through the ceiling and roof, as illustrated in figure 2, and by means

of doors and windows. During the curing period all ventilators were kept open. During the day the windows and doors also remained wholly or partially open unless the weather was cold or the atmosphere was very moist. By means of heat and ventilation, moisture was prevented from depositing on the interior of the stor-

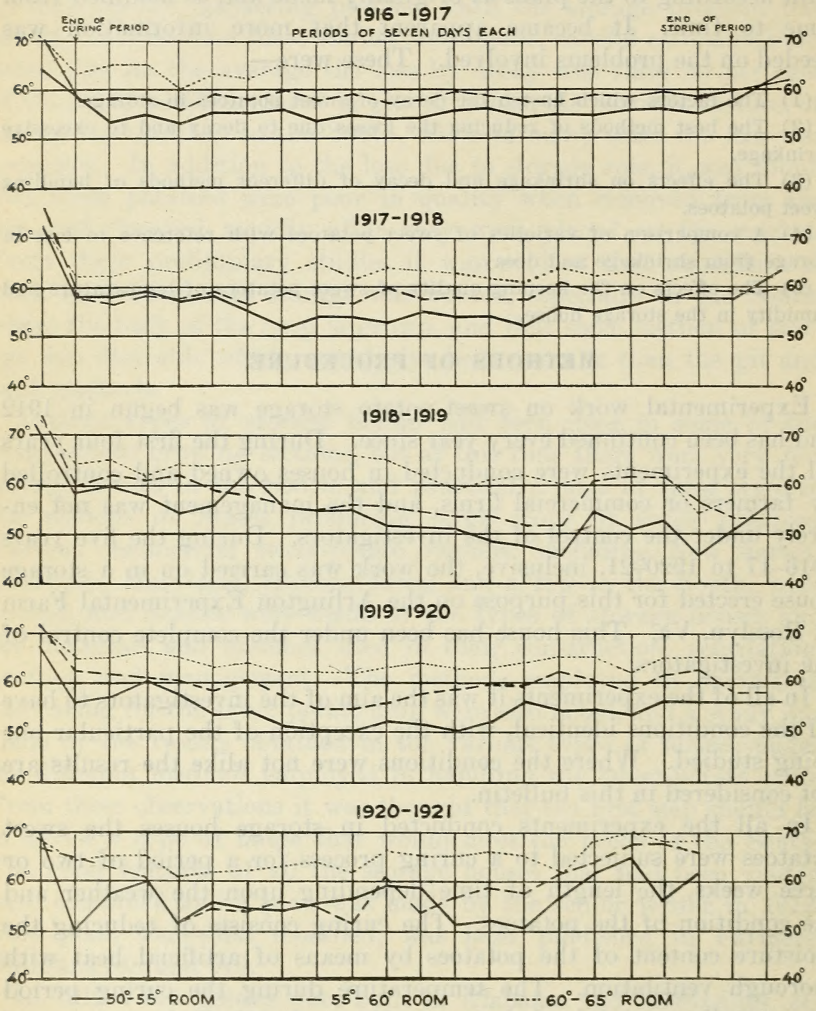


FIG. 1.—Diagrams showing the average temperature in the storage house at the Arlington Experimental Farm, Va.

age house. During rainy or cold weather the doors and windows of the house were kept closed.

Temperature and moisture variations in the experimental storage house were recorded by means of thermographs and hygrothermographs. These instruments were standardized by comparison be-

fore beginning work each year and checked at occasional intervals while in use; they were all of the 7-day type, and the record sheets were changed each Monday, thus giving a continuous record for each storage season.

The selection and the grading of the potatoes for each test were done by the investigators or by careful men under their direction. Shrinkage and decay were determined by weight. The percentages of shrinkage as recorded in the tables are progressive; that is, the record of loss at any period shows the total loss from harvest until that time.

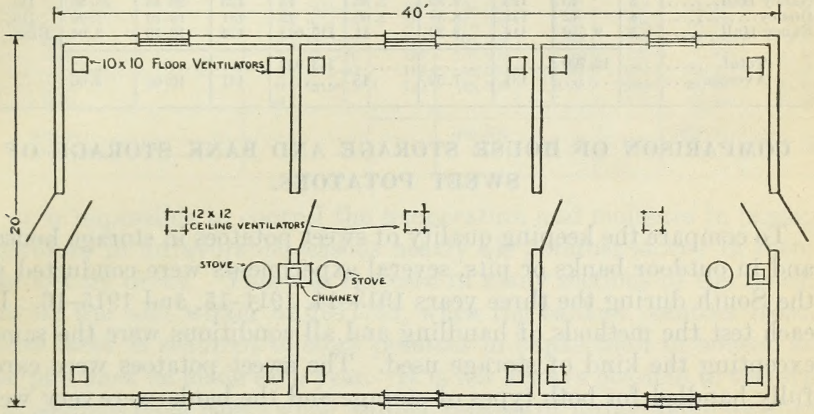


Fig. 2.—Plan of the experimental storage house at the Arlington Experimental Farm, Va.

COMPARISON OF THE KEEPING QUALITIES OF SWEET POTATOES UNDER CAREFUL AND UNDER COMMERCIAL HANDLING.

To determine the effects of methods of handling on the keeping qualities of sweet potatoes, five tests were made to compare careful handling in the field and in the storage house with ordinary commercial handling. These tests were all made in good houses in the South. The "careful handling" was done by men engaged in the experimental work, and all the conditions except the one under investigation were kept the same. Table 1 gives the results of the five tests in the four years 1912–13 to 1915–16, inclusive.

Attention is called to the fact that both crate storage and bin storage were used in the tests. Under careful handling the minimum shrinkage was 5 per cent and the maximum 9.39, the average being 7.52 per cent. The minimum shrinkage under commercial handling was 7.40 per cent and the maximum 20.40, with an average of 10 per cent. The average amount of decay was 0.45 per cent under careful handling and 3 per cent under commercial handling.

TABLE 1.—*Comparison of the keeping quality of sweet potatoes under careful and under commercial handling.*

[Shrinkage and decay averages for two varieties in five storage-house tests in Southern States during four seasons.]

Variety.	Test No.	Careful handling.				Commercial handling.				Storage receptacle.
		Weight at harvest time.	Time in storage.	Shrinkage.	Loss due to decay.	Weight at harvest time.	Time in storage.	Shrinkage.	Loss due to decay.	
		Pounds.	*Days.*	*Per cent.*	*Per cent.*	*Pounds.*	*Days.*	*Per cent.*	*Per cent.*	
Nancy Hall	1	3,062	161	5.00	0.50	3,062	161	7.40	1.00	Bins.
Dooley	2	120	125	9.10	.93	120	125	11.60	2.08	Crates.
Nancy Hall	3	45	125	9.39	5.56	45	125	20.40	15.56	Do.
Dooley	4	42	131	8.33	2.00	42	131	10.70	5.00	Do.
Nancy Hall	5	9,510	114	8.30	.41	110,663	114	10.10	3.04	Bins.
Total		12,799				113,932				
Average			131	7.52	.45		131	10.00	3.00	

COMPARISON OF HOUSE STORAGE AND BANK STORAGE OF SWEET POTATOES.

To compare the keeping quality of sweet potatoes in storage houses and in outdoor banks or pits, several experiments were conducted in the South during the three years 1913–14, 1914–15, and 1915–16. In each test the methods of handling and all conditions were the same, excepting the kind of storage used. The sweet potatoes were carefully handled for both types of storage and the banks were very well made; in fact, the banks were much better than the average. Sweet potatoes are not stored in banks in the North and to only a small extent in the colder portions of the South. In regions where freezing occurs sweet potatoes stored outdoors in any kind of banks are in danger of chilling, even though protected from freezing. Table 2 gives the results of storing 10 lots of sweet potatoes in houses and in banks.

Table 2 shows that the percentage of decay of sweet potatoes stored in houses ranged from 0.5 to 2 per cent. In banks the variation was from 4 to 40 per cent. The average decay of all the tests was 1.2 per cent in houses and 14.33 per cent in banks. The length of time the comparable lots of sweet potatoes were in storage was not always the same, but where there was a difference the shorter period was for those in the banks. As already suggested, the potatoes stored in these particular banks kept in much better condition than in the usual banks. This was due to the careful handling of the potatoes and to the making of good banks.

Many ordinary banks and pits of potatoes were examined during these studies. Generally the proportion of decay was between 25 and 50 per cent, and in some cases 100 per cent.

TABLE 2.—*Relation of the place of storage to the keeping quality of sweet potatoes.*

[Percentage of loss due to decay in a storage house and in outdoor banks and pits.]

Variety.	Test No.	Year.	In storage house.			In banks or pits.		
			Time in storage.	Weight at harvest time.	Loss due to decay.	Time in storage.	Weight at harvest time.	Loss due to decay.
			Days.	*Pounds.*	*Per cent.*	*Days.*	*Pounds.*	*Per cent.*
Triumph	1	1913–14	137	6,000	0.60	124	42,000	10.00
Nancy Hall	2	1914–15	106	84,000	.60	106	4,500	17.30
Nancy Hall	3	1915–16	118	48,000	1.50	102	18,000	33.30
Nancy Hall	4	1915–16	103	90,000	2.00	103	30,000	11.60
Triumph	5	1915–16	115	372,000	1.50	108	12,000	7.30
Nancy Hall	6	1915–16	110	168,000	.60	110	6,000	6.50
Nancy Hall	7	1915–16	123	120,000	50	120	1,800	6.40
Mixed varieties	8	1915–16	114	48,000	1.00	114	60,000	4.00
Nancy Hall	9	1915–16	110	48,000	1.75	110	18,000	35.00
Nancy Hall	10					110	12,000	40.00
Total				984,000			204,300	
Average			115		1.20	111		14.33

It is impossible to control the temperature and moisture in banks, therefore in unfavorable seasons nearly all potatoes stored in them are lost by decay. This was the case in many sections of the South during the cold winter of 1917–18, when the banked potatoes froze. More labor is required to store potatoes in banks than in houses, as the pits must be made each year. It is not always possible to remove the potatoes from banks when wanted, because of unfavorable weather conditions, as it is not safe to open a bank of potatoes during cold or rainy weather. Potatoes which have been stored in banks are of low quality and decay rapidly, probably owing to lack of complete curing resulting in a watery potato. But even if potatoes stored in banks kept as well as those in storage houses, it would still be desirable to store in houses because of their greater convenience.

COMPARISON OF THE KEEPING QUALITIES OF INJURED AND UNINJURED SWEET POTATOES.

Some injury will result even with the most careful methods of harvesting and handling sweet potatoes. The plow or other harvesting implement cuts and bruises some of the potatoes. Some bruising is incidental to handling in the field and in storing. To determine the effects of cutting and bruising on shrinkage and decay in storage, potatoes injured at digging time were sorted and kept separate. For comparison, lots of uninjured potatoes of the same varieties were kept under like conditions. Three standard varieties were used in this experiment, which was conducted in the experimental storage house at the Arlington Experimental Farm. The results of this experiment are given in Table 3.

TABLE 3.—*Relation of cut or bruising injury to the keeping quality of sweet potatoes.*

[Shrinkage and decay averages for three varieties kept at a temperature of 50° to 55° F., seasons of 1917–18 and 1918–19.]

Variety and condition.	Average weight at harvest time.	Shrinkage during curing, 19 days.	Shrinkage at end of—					Weight at end of storage period.	Loss due to decay, 164 days.	
			51 days.	82 days.	111 days.	141 days.	164 days.			
Uninjured:	*Pounds.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*
Big-Stem Jersey	142.56	6.59	8.02	9.42	10.88	12.09	13.54	123.25	1.81	1.27
Nancy Hall	140.00	7.14	8.46	9.69	11.03	12.12	13.10	121.56	.84	.60
Southern Queen	153.09	7.83	9.12	10.49	12.00	13.21	14.69	130.59	.59	.38
Total	435.66							375.41	3.25	
Average		7.23	8.55	9.88	11.33	12.49	13.83			.75
Injured, cut, and bruised:										
Big-Stem Jersey	73.25	14.44	19.75	23.59	27.09	30.33	33.83	48.47	20.16	27.52
Nancy Hall	46.06	18.52	21.51	23.88	26.19	27.99	29.51	32.47	4.28	9.29
Southern Queen	71.97	12.55	14.67	16.54	18.64	20.06	21.88	56.53	1.94	2.69
Total	191.28							137.47	26.38	
Average		14.83	18.26	21.01	23.69	25.91	28.13			13.79

Every potato in the damaged lots was either cut or bruised. Table 3 shows that for every period the shrinkage of the injured sweet potatoes was much greater than that of the uninjured ones. The exposure of the cut surfaces and the drying up of the decayed sweet potatoes caused a higher shrinkage in the injured lots. At the end of the storage period the average shrinkage of the three varieties was 28.13 per cent for the injured and 13.83 per cent for the uninjured potatoes. The Big-Stem Jersey variety showed the highest percentage of shrinkage and also the largest proportion of decay in the injured lots. The Southern Queen had the smallest percentage of shrinkage of the injured lots. The extent of decay was considerably greater in the injured than in the uninjured lots. The average loss for the three varieties was 0.75 per cent in the uninjured lots and 13.79 per cent in the injured lots. The greatest loss was in the Big-Stem Jersey, being 27.52 per cent in the injured lot in comparison with 1.27 per cent for those not injured. The proportion of decay in the injured lot of the Southern Queen variety was very small, being only 2.69 per cent, or less than one-third as much as in the Nancy Hall and less than one-ninth as much as in the Big-Stem Jersey. It is a matter of common observation that the Southern Queen will stand rough handling better than any of the other standard varieties. The cut surfaces of this variety heal rapidly under good storage conditions. It should not be inferred, however, that great care in handling it is not important, for under less favorable conditions the loss might be much higher. The excessive shrinkage and the poor appearance of the injured potatoes reduce their market value materially and are of sufficient importance to justify

careful handling. The conditions under which this experiment was conducted were more favorable than would ordinarily exist in commercial practice. The loss due to decay was not as great as would usually occur. Under ordinary conditions the cut and bruised sweet potatoes should be disposed of at harvest time.

COMPARISON OF THE PRACTICES OF SORTING AND NOT SORTING STORED SWEET POTATOES.

It has been very generally believed that when sweet potatoes begin to decay in storage they should be sorted to pick out the diseased ones. Observations on this point indicated that this sorting was of doubtful value. Experiments were begun in 1912 and continued in each of four years to determine whether it is safe to pick out the diseased sweet potatoes. The sorting was carefully done, so as to avoid bruising as much as possible, about once a month during the storage period.

In all, seven tests, including three varieties, were made. The average storage period for all of these experiments covered 134 days. The results are given in Table 4.

TABLE 4.—*Relation of sorting to the keeping quality of sweet potatoes.*

[Shrinkage and decay averages for three varieties in seven storage-house tests in Southern States during four seasons.]

Variety.	Year.	Sorted.					Not sorted.				
		Weight at the beginning.	Time in storage.	Weight at end of storage period.	Shrinkage.	Loss due to decay.	Weight at the beginning.	Time in storage.	Weight at end of storage period.	Shrinkage.	Loss due to decay.
		Lbs.	*Days.*	*Lbs.*	*Per cent.*	*Per cent.*	*Lbs.*	*Days.*	*Lbs.*	*Per cent.*	*Per cent.*
Dooley	1912–13	300	125	272. 4	9. 2	0. 93	300	125	272. 79	9. 30	0. 74
Nancy Hall	1912–13	50	182	39. 0	22. 0	6. 00	50	182	40. 00	20. 00	4. 00
Dooley	1913–14	847	106	759. 76	10. 3	2. 70	2, 527	106	2, 239. 93	11. 36	1. 20
Do	1913–14	42	131	36. 25	13. 7	5. 00	42	131	38. 26	8. 90	2. 00
Nancy Hall	1913–14	42	125	34. 57	17. 7	4. 40	42	125	36. 67	12. 70	1. 11
Big-Stem Jersey	1914–15	36	152	32. 00	11. 1	8. 00	36	152	32. 11	10. 80	2. 00
Nancy Hall	1915–16	32	103	29. 06	9. 2	.....	29	103	26. 74	7. 80	.....
Total	.....	1, 349	.....	1, 203. 04	.....	.....	3, 026	.....	2, 686. 50	.....	.....
Average	.....	.....	132	.....	10. 82	2. 63	.....	132	.....	11. 24	1. 21

Except in one experiment with the Nancy Hall variety, the decay was greater in the sorted lots than in those not sorted. The average decay of the sorted lots was 2.63 per cent and of those unsorted 1.21 per cent. Under less careful handling there would probably have been more decay in both sorted and unsorted lots, but especially in the former. No definite explanation can be given for the larger percentage of decay in sweet potatoes that were sorted, but it is possible that slight bruising resulted from handling, and that the sorting increases the chance of spreading disease from decayed to

sound sweet potatoes. One decayed sweet potato left undisturbed might be in contact with several sound ones, all of which would eventually become diseased, but it would require considerable time for all of these to decay completely. When sorted, each of the potatoes which had become infected with disease might be placed in contact with several uninfected ones, thereby spreading the disease to them.

Since sorting increases disease injury and in addition requires considerable labor, it seems inadvisable to disturb sweet potatoes until they are to be placed on the market. Should decay appear to be serious, the potatoes should be sorted and, if the market is at all satisfactory, disposed of immediately.

COMPARISON OF THE KEEPING QUALITIES OF VARIOUS VARIETIES OF SWEET POTATOES.

Experiments were begun in 1916 to determine the shrinkage and decay in storage of the most important varieties of sweet potatoes grown in the United States. These experiments were conducted in the storage house at the Arlington Experimental Farm, Va. The sweet potatoes were placed in bushel crates in the field and hauled to the storage house. At the house they were cleaned by wiping each potato with a soft cloth. The potatoes were then placed in weighed crates, and a second weighing showed the quantity stored. Only one crate of a variety was used in these experiments, and with some varieties there was not always a full crate. During the curing period, which averaged 20 days, the temperature was maintained between 80° and 95° F. After this it was gradually reduced and maintained between 50° and 55° F. for the remainder of the storage period. The crates of potatoes were weighed once each week during the curing period and approximately once a month thereafter through the storage period. One year the weights were taken every day during the curing and once a week throughout the remainder of the storage period. As the differences from day to day during curing and from week to week throughout the storage period were rather slight, the figures given are based on the weights at the end of curing and at monthly intervals thereafter. The results for the four years 1916–17 to 1919–20, inclusive, are given in Table 5.

Table 5 shows that the average shrinkage during the curing period was 7.97 per cent. The lowest shrinkage was 6.07 per cent for the Big-Stem Jersey, and the highest 10.27 per cent for the Gold Skin. It is worth noting that these varieties belong in the same group. Excepting the Gold Skin, all the varieties in the Jersey group were low to medium in shrinkage during the curing period. Of the other important varieties, the shrinkage during the curing period was as

follows: Triumph, 6.75; Porto Rico, 7.10; Nancy Hall, 6.77; Southern Queen, 7.10; Pumpkin "Yam," 8.51; Dooley, 9.62; Red Jersey, 6.34; and Yellow Jersey, 7.11 per cent.

Shrinkage continued throughout the storage period, but was greatest during the curing period, and the rate gradually decreased to the end of storage. The shrinkage due to loss of moisture during the curing period, which averaged 20 days, was nearly half the loss for the entire storage period of 160 days.

The average loss in weight for all varieties for the entire storage period was 16.52 per cent, the lowest being 12.96 per cent for the Pierson and the highest 21.01 per cent for the Gold Skin variety. The heavy loss in the latter was caused largely by the drying of decayed potatoes. The sweet potatoes in this experiment were in storage for a longer period than is usual in commercial houses. In fact, the average storage period for sweet potatoes is probably not more than three months, since marketing usually begins soon after the potatoes are stored and continues until all are removed. Very few sweet potatoes remain in storage longer than four months, so that the 113-day period is more nearly comparable to commercial storage than 160 days.

TABLE 5.—*Relation of variety to the keeping quality of sweet potatoes stored in crates.*

[Shrinkage and decay averages in storage-house tests during four seasons.]

Variety.	Average weight of potatoes at harvest time.	Shrinkage during curing, 20 days.	Shrinkage at end of—					Loss due to decay for 160 days.
			50 days.	83 days.	113 days.	142½ days.	160 days.	
	Pounds.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
White Sealy [1]	36.81	7.03	8.15	9.67	10.87	11.98	13.15	.....
Belmont	34.61	8.44	10.57	12.05	13.41	15.00	16.44	1.08
Georgia (old-time "yam")	36.92	8.80	10.83	12.62	14.52	15.58	17.63	.32
Yellow "Yam"	45.44	7.57	10.50	12.28	14.15	15.74	16.81	.11
Vineless Pumpkin "Yam" [2]	45.95	7.05	9.10	10.86	12.58	14.49	15.58	.35
Pierson	46.91	7.08	8.37	9.83	10.98	12.13	12.96	.....
Yellow Strasburg	48.00	7.06	9.08	11.06	12.37	13.42	14.46	.02
Triumph	43.23	6.75	8.28	9.60	11.38	12.40	12.98	.25
Haiti	45.34	6.81	11.80	13.98	16.01	17.73	18.64	2.45
Red Bermuda	50.25	7.64	9.73	11.36	12.84	14.31	15.24	.72
Red Brazil	49.50	7.98	10.38	12.24	14.08	15.55	16.89	2.18
Key West	40.73	9.43	11.12	12.74	14.66	17.01	17.75	.38
Porto Rico	44.53	7.10	8.87	11.05	13.09	14.24	15.29	.13
Creola	31.94	7.89	9.46	10.92	12.15	13.65	15.47	.19
Dahomey	40.41	7.55	9.11	10.34	11.51	12.69	13.73	.07
Florida	48.34	7.34	9.33	10.98	12.47	13.90	14.87	1.39
General Grant Vineless	46.39	7.50	9.59	11.25	13.00	14.49	15.43	.....
Nancy Hall	45.23	6.77	8.31	9.73	11.43	12.53	13.60	.....
White "Yam"	47.03	7.80	9.44	10.99	12.59	13.93	14.88	.40
Southern Queen	44.78	7.10	8.84	10.38	11.89	13.03	14.09	.02
Pumpkin "Yam"	43.94	8.51	11.17	13.27	15.59	17.32	18.57	2.64
Norton	31.62	8.73	13.35	15.50	18.37	19.26	20.46	1.58
Dooley	41.59	9.62	12.36	14.11	16.49	18.22	19.86	.34
Red Jersey	41.64	6.34	7.80	9.46	11.45	12.68	14.75	.14
Big-Stem Jersey	47.97	6.07	8.06	10.11	11.90	13.51	14.43	3.65
Yellow Jersey [1]	45.15	7.11	8.57	10.19	12.03	13.49	14.88	1.37
Gold Skin [2]	44.02	10.27	12.88	14.99	17.56	19.45	21.01	8.66
Average for all varieties.	43.27	7.97	10.20	11.99	13.82	15.31	16.52	1.10

[1] Average for only two years. [2] Average for only three years.

The loss due to decay in this experiment was very small, the average being only 1.10 per cent for all varieties. Among the varities tested, those showing the greatest loss were the Gold Skin, 8.66; Big-Stem Jersey, 3.65; Pumpkin "Yam," 2.64; Haiti, 2.45; and Red Brazil, 2.18 per cent. Of the 27 varieties in the experiment 4 showed no decay; 7 varieties had a loss between 0.02 and 0.25 per cent; 6 varieties between 0.25 and 0.50 per cent; 1 variety 0.72 per cent; 4 varieties between 1 and 2 per cent, and the others showed losses between 2.18 and 8.66 per cent.

The conditions in the storage room were nearly ideal; therefore the loss due to decay was so slight that differences between varieties mean very little.

Several varieties, chiefly those belonging to the Jersey group, namely, Red Jersey, Big-Stem Jersey, Yellow Jersey, and Gold Skin, though not showing excessive decay, had begun to deteriorate and from a commercial point of view should have been removed sooner.

COMPARISON OF THE KEEPING QUALITIES OF SWEET POTATOES WHEN STORED AT DIFFERENT TEMPERATURES.

To determine the effects of different temperatures on the keeping qualities of sweet potatoes, experiments were conducted during 1917–18 and 1918–19. Three standard varieties of sweet potatoes were stored in each of three different rooms, where after the curing period it was the plan to maintain the temperature between 50° and 55° F., 55° and 60° F., and 60° and 65° F., respectively. The aim during curing was to keep the temperature high enough to cure the potatoes properly, all three rooms being treated alike. After the curing period the temperature was gradually lowered in each room and an effort made to maintain it between the points mentioned. The average weekly temperature usually varied only a few degrees, as shown in figure 1.

The shrinkage of sweet potatoes at the end of the curing period and at various intervals during storage and the percentage of loss due to decay are shown in Table 6.

Table 6 shows that under all temperatures about half the shrinkage occurred during the curing period. After the curing period the shrinkage continues, but the rate is rather slow, averaging less than 1½ per cent a month under the three sets of temperatures. Comparing the average percentage of shrinkage under the three different temperatures, it is seen that it is greater at the higher temperatures. The difference between the first two sets is especially noticeable, and is just as noticeable with the Big-Stem Jersey and Nancy Hall varieties in the third set. The Southern Queen showed less shrinkage at 60° to 65° F. than at any other temperature. The average total shrinkage of

the three varieties for the storage period of 164 days was 13.83 per cent when stored at 50° to 55° F., 15.27 per cent at 55° to 60° F., and 15.70 per cent at 60° to 65° F. These percentages are fairly low for such a long storage period, especially for storage in crates. At 111 days in this experiment, this period being comparable to the time sweet potatoes are ordinarily held in storage, the average percentage of shrinkage was 11.33 at 50° to 55° F., 12.47 at 55° to 60° F., and 13.22 at 60° to 65° F.

TABLE 6.—*Relation of temperature during storage ot the keeping quality of sweet potatoes.*

[Shrinkage and decay averages of three standard varieties in storage-house tests during two seasons.]

Variety.	Temperature.	Weight[1] at harvest time.	Loss in weight during curing.	Loss in weight at end of—						Loss due to decay in 164 days.	
				51 days.	82 days.	111 days.	141 days.	164 days.			
	°F.	Lbs.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Lbs.	Per ct.	Lbs.	Per ct.
Big-Stem Jersey	50 to 55	142.56	6.59	8.02	9.42	10.88	12.09	19.31	13.54	1.81	1.27
Nancy Hall	50 to 55	140.00	7.14	8.46	9.69	11.03	12.12	18.44	13.10	.84	.60
Southern Queen	50 to 55	153.09	7.83	9.12	10.49	12.00	13.21	22.50	14.69	.59	.38
Total for three varieties		435.67						60.25		3.25	
Average for three varieties			7.23	8.55	9.88	11.33	12.49		13.83		.75
Big-Stem Jersey	55 to 60	144.16	7.74	9.02	10.82	12.59	14.24	22.50	15.61	1.69	1.17
Nancy Hall	55 to 60	144.47	8.50	9.73	11.12	12.74	14.30	22.31	15.45	.72	.49
Southern Queen	55 to 60	151.72	8.71	9.68	11.53	12.09	14.03	22.44	14.79	.56	.37
Total for three varieties		440.34						67.25		2.97	
Average for three varieties			8.32	9.48	11.16	12.47	14.18		15.27		.67
Big-Stem Jersey	60 to 65	139.94	7.98	9.60	12.10	13.75	15.46	23.62	16.85	3.31	2.36
Nancy Hall	60 to 65	143.16	9.17	11.05	13.18	14.69	15.89	24.12	16.85	.78	.54
Southern Queen	60 to 65	150.53	6.73	8.24	10.40	11.73	12.81	20.34	13.51		
Total for three varieties		433.62						68.09		4.09	
Average for three varieties			7.93	9.61	11.87	13.22	14.68		15.70		.96

[1] Weight means the average weight of potatoes stored per year (total weight divided by 2).

Toward the end of the storage period the Big-Stem Jersey usually withers at the tips, while the two other varieties remain plump. The Southern Queen retains its plumpness better than the others. For this reason Jersey varieties are usually marketed first.

KEEPING QUALITIES OF SWEET POTATOES STORED IN BINS AND IN CRATES.

Sweet potatoes may be stored in bins, or in crates, boxes, hampers, baskets, or other containers. It is often asserted that crates, baskets, and other containers are better than bins, because when decay sets in it is likely to be confined to the container holding only a small quan-

tity; but in bins the decay is likely to spread throughout the large bulk of the potatoes. It is asserted also that less injury occurs in handling where small containers are used, because the potatoes are placed in the receptacles in the field and are not disturbed until prepared for market; but when stored in bins the potatoes are gathered in baskets and dumped into bins, and some bruising will occur even with the most careful workers. In ordinary commercial handling there is considerable bruising.

Experiments were begun in 1917 to study the shrinkage and decay in three standard varieties of sweet potatoes stored in 1-bushel crates and in bins. The bins used were about 4 feet wide, 8 feet long, and 7 feet high, although the potatoes were seldom more than 5 feet deep in the bins. After the potatoes were plowed out they were placed in 1-bushel crates and hauled directly to the storage house. Those put in bins were first cleaned and weighed. The potatoes intended for the crate experiments were cleaned and placed in weighed crates, and the total weight was then recorded. The crates were not disturbed until the end of the storage season. In the room where these experiments were conducted the temperature was maintained between 55° and 60° F. The average temperature in this room is shown in figure 1.

Table 7 presents the results of these experiments for 1917–18 and for 1918–19.

TABLE 7.—*Relation of the storage receptacle to the keeping quality of sweet potatoes.*

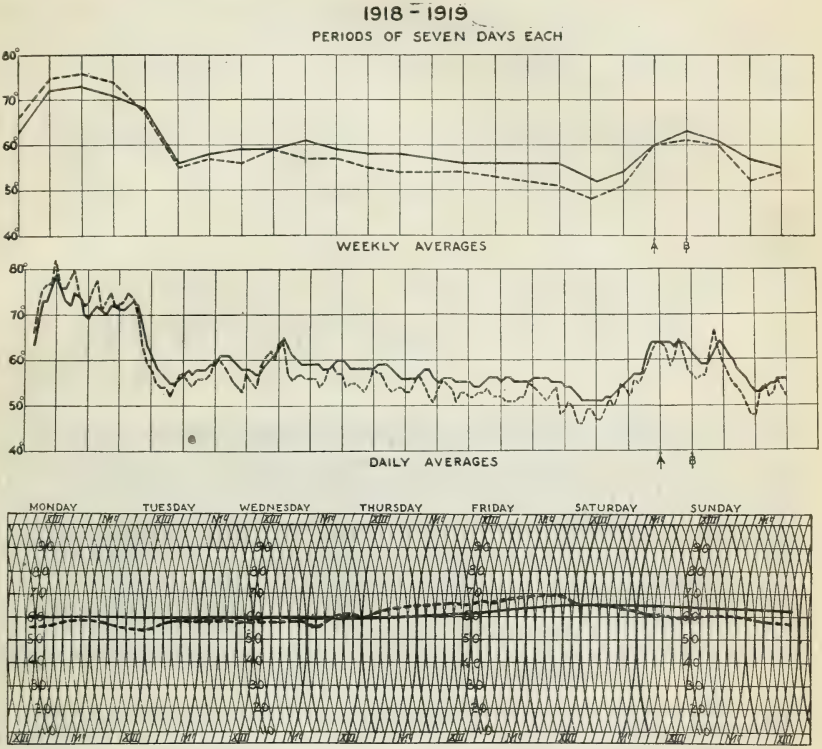
[Shrinkage and decay averages of three standard varieties stored in bins and in crates during two seasons.]

Variety.	Storage receptacle.	Time in storage.	Average weight at—		Loss in weight due to shrinkage.		Loss in weight due to decay.	
			Harvest time.	End of storage period.				
		Days.	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
Big-Stem Jersey	Bin	171½	3,000.90	2,586.59	414.31	13.80	65.59	2.18
	Crate	154	144.16	121.66	22.50	15.61	1.69	1.17
Nancy Hall [1]	Bin	172	3,970.56	3,506.69	463.87	11.18	19.94	.50
	Crate	162	131.94	117.00	14.94	11.32	.19	.14
Southern Queen	Bin	171½	2,930.75	2,533.59	397.15	13.55	13.53	.48
	Crate	154	151.72	129.28	22.44	14.79	.56	.37
Average for three varieties	Bin	171½	9,902.22	8,626.87	1,275.34	12.88	99.06	1.00
	Crate	156¼	427.81	367.94	59.87	14.02	2.47	.57

[1] Only one year, 1918–19.

Table 7 shows that the average shrinkage for the three varieties was greater in crates than in bins, although the difference was not as great as is commonly supposed. The average percentage of decay was a little greater in the bins than in the crates, although it was so slight that the difference is not of great importance. Under less favorable conditions the differences might be greater.

The sweet potatoes in the bins were kept longer than those in crates. If the latter had been kept the full length of time (171½ days) the shrinkage would have been a little greater, since during the last month of storage the average shrinkage of the three varieties at 55° to 60° F. was a little more than 1 per cent, as shown in Table 6. The results with the Nancy Hall are for one year only, since



THERMOGRAPH SHEET FOR THE PERIOD A–B.

FIG. 3.—Diagrams showing the temperature in the interior of the bins (solid lines) as compared to the temperature of the air (broken lines) in 1918–19 at the Arlington Experimental Farm, Va. The upper diagram gives the average temperature for the storage season, by weekly periods. The middle diagram gives the same data by daily averages. In these diagrams each square indicates a period of seven days. The lower diagram is a typical thermograph sheet, in this case for the period A–B.

there was no bin test of this variety in 1917–18. The shrinkage of this variety was low in both the bins and crates in 1918–19.

RELATION OF THE TEMPERATURE IN THE BINS TO THE TEMPERATURE OF THE SURROUNDING AIR.

Air-soil thermographs were employed to ascertain the differences, if any, between the temperature in the center of the bins and the temperature of the air in the storage house. Figures 3 and 4 show

the temperatures in the bins and of the air recorded by the instruments and averaged by 2-hour periods for the years 1918–19 and 1919–20, respectively. The variety used was the Southern Queen, and the bin contained about 75 bushels each year. The average temperature in the bins was somewhat higher than that of the air, and the fluctuations in temperature were less marked in

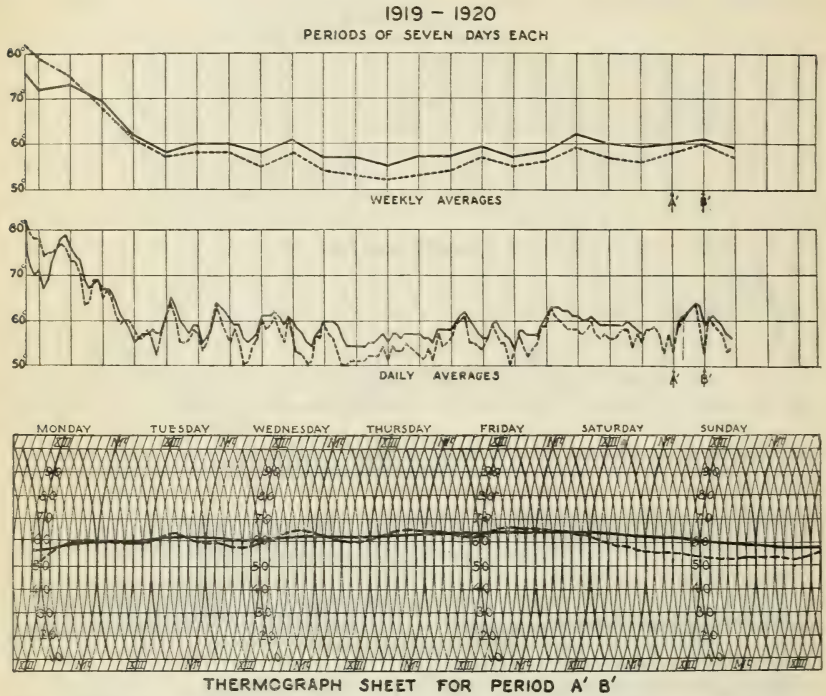


FIG. 4.—Diagrams showing the temperature in the interior of the bins (solid lines) as compared to the temperature of the air (broken lines) in 1919–20 at the Arlington Experimental Farm, Va. The upper diagram gives the average temperature for the storage season, by weekly periods. The middle diagram gives the same data by daily averages. In these diagrams each square indicates a period of seven days. The lower diagram is a typical thermograph sheet, in this case for the period A'–B'.

the bins than in the air. Some work was done in studying the temperature of the bins as compared with that of standard bushel crates, but owing to its incompleteness the results are not presented here. In general, the temperature in the crates was about the same as that of the surrounding air and somewhat lower than the temperature of the interior of the bins.

COMPARISON OF THE KEEPING QUALITIES OF FOUR IMPORTANT COMMERCIAL VARIETIES OF SWEET POTATOES STORED UNDER LIKE CONDITIONS.

Experiments were begun in 1917 to determine the relative keeping qualities of the more important commercial varieties of sweet potatoes. The Southern Queen, Nancy Hall, Big-Stem Jersey, and Porto Rico varieties were used in this experiment, and the purpose of the workers was to store these in bins in sufficiently large quantities to be comparable with commercial conditions. (Table 8.)

TABLE 8.—*Comparison of the keeping qualities of four standard varieties of sweet potatoes stored in bins.*

[Shrinkage and decay averages at a temperature of 50° to 55° F. during four seasons.]

Variety and year.	Room No.	Weight at—		Loss in weight.	Shrinkage.	Weight of decayed potatoes.	Decay.	Time in storage.
		Harvest time.	End of storage period.					
Southern Queen:		*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Days.*
1917–18	3	2,512.50	2,119.37	393.12	15.65	20.56	0.82	171
1918–19	3	3,349.00	2,947.81	401.19	11.98	6.50	.19	172
1919–20	3	2,217.81	1,984.75	233.06	10.51	8.94	.40	159
1920–21	3	1,498.75	1,397.25	101.50	6.77	2.00	.13	164
Total		9,578.06	8,449.19	1,128.87		38.00		
Average					11.79		.40	166½
Nancy Hall: [1]								
1918–19	3	3,970.56	3,506.69	463.87	11.69	19.94	.50	172
1919–20	3	1,657.62	1,528.37	129.25	7.80	13.25	.80	159
1920–21	3	1,498.50	1,407.12	96.37	6.43	11.75	.79	165
Total		7,126.69	6,442.19	689.50		44.94		
Average					9.67		.63	165⅓
Hig-Stem Jersey:								
1917–18	3	1,931.50	1,699.50	232.00	12.01	91.94	4.76	171
1918–19	3	4,070.31	3,473.69	596.62	14.66	39.25	.96	172
1919–20	3	2,533.44	2,175.25	358.19	14.14	87.31	3.05	159
1920–21	3	1,498.25	1,384.50	113.75	7.59	1.50	.10	165
Total		10,033.50	8,736.94	1,300.56		220.00		
Average					12.96		2.19	166½
Porto Rico: [2]								
1919–20	3	2,429.06	2,111.31	317.75	13.08	18.00	.85	151
1920–21	3	1,497.50	1,336.50	161.00	11.42	5.25	3.50	166
Total		3,726.56	3,447.81	478.75		23.25		
Average					12.82		.62	158½

[1] Results for three years only.

[2] Results for two years only.

For the Southern Queen the average storage period was 161½ days, the average shrinkage 11.79 per cent, and the average decay 0.40 per cent. The figures for the Nancy Hall are for three years only and show an average shrinkage of 9.67 per cent and 0.63 per cent decay for the average storage period of 165⅓ days. The work on the Big-Stem Jersey was carried on for four years and showed 12.96 per cent

shrinkage and 2.19 per cent decay for the storage period of 166¾ days. The results with the Porto Rico variety for two years showed 12.82 per cent shrinkage, with 0.62 per cent decay for the storage period of 158½ days.

SUMMARY.

With careful handling it is possible to store and keep sweet potatoes for four months with losses as low as 7.52 per cent from shrinkage and decay. With ordinary commercial handling these losses ran as high as 20.40 per cent and averaged 10 per cent. (See Table 1.)

Sweet potatoes stored in houses lost from 0.5 per cent to 2 per cent from decay, while like sorts stored in banks and pits showed a loss of from 4 to 40 per cent. (See Table 2.)

Sweet potatoes injured in harvesting and handling lost 28.13 per cent by shrinkage, and stock that was carefully handled lost 13.83 per cent. (See Table 3.)

Sweet potatoes sorted from time to time during the storage period showed greater losses from decay than those not sorted. (See Table 4.)

Storage tests with single crates of each of all the important varieties of sweet potatoes showed that the shrinkage during the curing period varied from 6.07 to 10.27 per cent. The average loss in weight for all varieties for the storage period was 16.52 per cent, the lowest being 12.96 per cent and the highest 21.01 per cent. (See Table 5.)

Sweet potatoes stored at 50° to 55° F. lost 13.83 per cent in weight; those stored at 55° to 60° F. lost 15.27 per cent, and those stored at 60° to 65° F. lost 15.70 per cent. (See Table 6.)

In these experiments sweet potatoes of the Nancy Hall, Southern Queen, and Big-Stem Jersey varieties stored in crates showed greater shrinkage than similar stock stored in bins. (See Table 7.)

The average temperature in bins filled with sweet potatoes is higher than that of the surrounding air. (See figs. 3 and 4.)

When stored in bins under uniform conditions the Southern Queen variety showed the least decay, the Porto Rico and Nancy Hall were about equal, and the Big-Stem Jersey decayed most of any of these four varieties. In shrinkage the Nancy Hall was lowest, the Southern Queen next, the Porto Rico next, and the Big-Stem Jersey was highest. (See Table 8.)

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